BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: Mobility Requirements for AAP Lunar Surface Missions
Case 232

DATE: August 21, 1967

FROM: C. J. Byrne

ABSTRACT

The sixteen AAP lunar landing targets of Lunar Orbiter V are analysed to determine mobility requirements for surface missions.

In order to visit all features of interest, a mobility system with a total effective range of 132 km and an operating radius of 25 km would be required.

If only two features were to be visited on each landing mission, a total effective range of 30 km and an operating radius of 8 km would be sufficient.

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(NASA-CR-89395) MOBILITY REQUIREMENTS FOR AAP LUNAR SURFACE MISSIONS (Bellcomm, Inc.) 21 p

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MEMORANDUM FOR FILE

I. INTRODUCTION

The sixteen AAP targets of Lunar Orbiter V form the pool of potential landing sites for AAP missions. In a recent paper, F. El Baz examined Lunar Orbiter IV photography of these sites (about 60 meters resolution), tentatively choosing a touchdown point and features of scientific interest for ground missions*. The touchdown points were chosen for apparent smoothness of touchdown and approach path and for a central location close to several features of interest.

The ground missions would require a mobility system to extend an astronaut's operating range. The purpose of this paper is to examine the sites to determine the minimum required range capabilities of such a system.

It is recognized that examination of high resolution data from Lunar Orbiter V and more detailed mission planning will result in a refinement of this study.

II. DISTANCE STATISTICS

For each landing site, the distances from the chosen touchdown point to each feature of scientific interest were measured on unrectified Lunar Orbiter IV photographs (reproduced from the memorandum of F. El Baz in Figures 1 to 10). The distances were scaled from the 10 km line in the figures.

The following special rules were observed:

1. Where two touchdown points are described for a single site, the northern one is designated (a) and the southern one (b).

2. Where several features of the same type are present, only the distance to the feature nearest to the touchdown point is measured.

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*El Baz, F., Lunar Orbiter Mission V: Potential AAP Landing Sites, Bellcomm Memorandum for File, July 26, 1967.

The measurements are summarized in Table I. In addition to the measurements of each feature of interest, the sum of all distances for a particular site is determined and the sum of distances for the two nearest features on each site is determined.

Two sets of histograms have been plotted, for two types of missions (see Figures 11 and 12). In the complete missions, all features of interest are visited for a particular landing site. A star pattern is used; one excursion, out and back, is carried out for each feature. In the 2-feature missions only the two nearest features are visited.

III. CONCLUSIONS

It should be emphasized that the conclusions that can be drawn at this stage are tentative because the missions are based on low resolution data. Furthermore only the complete mission was envisioned in designating points of interest and the touchdown point. A definitive study must await detailed mission planning based on high resolution photographs.

However, to provide interim estimates of mobility requirements, the following inferences can be drawn from the histograms and associated site photography:

1. A mobility system with a 25 km maximum one-way effective range (50 km round trip) could visit all points of interest. A system with a 16 km maximum one-way effective range could visit 95% of all features of interest. The eliminated sites would be mostly in highlands.

2. The total round-trip effective range required to visit all features is 132 km.

3. For the 2-feature mission, an 8 km maximum one-way effective range is sufficient for all sites.

4. The total round trip effective range required for 2-feature missions at all sites is 30 km.

From these tentative conclusions, one would be led to carry two levels of vehicle performance through study; one with a total effective range of about 150 km and an operating radius of 25 km and the other with a total effective range of about 30 km and an operating radius of 8 km. Of course, safety margins, an allowance for non-straight paths due to obstacle avoidance and exploration deviations, and guidance errors must be added. These two sets of requirements need not imply separate vehicle designs; they may only imply different power or fuel recharging and operational strategies.

A third possible mission type, requiring mobility from one landing site to another, is not covered in this study.

C J Byrne

1012-CJB-ljb C. J. Byrne

Attachments:
Table I
Figures 1-12

ACKNOWLEDGEMENTS

The author is indebted to Mrs. K. Jackson for the measurements, calculations, and preparation of histograms.

TABLE A

Distances of Points of Scientific Interest From

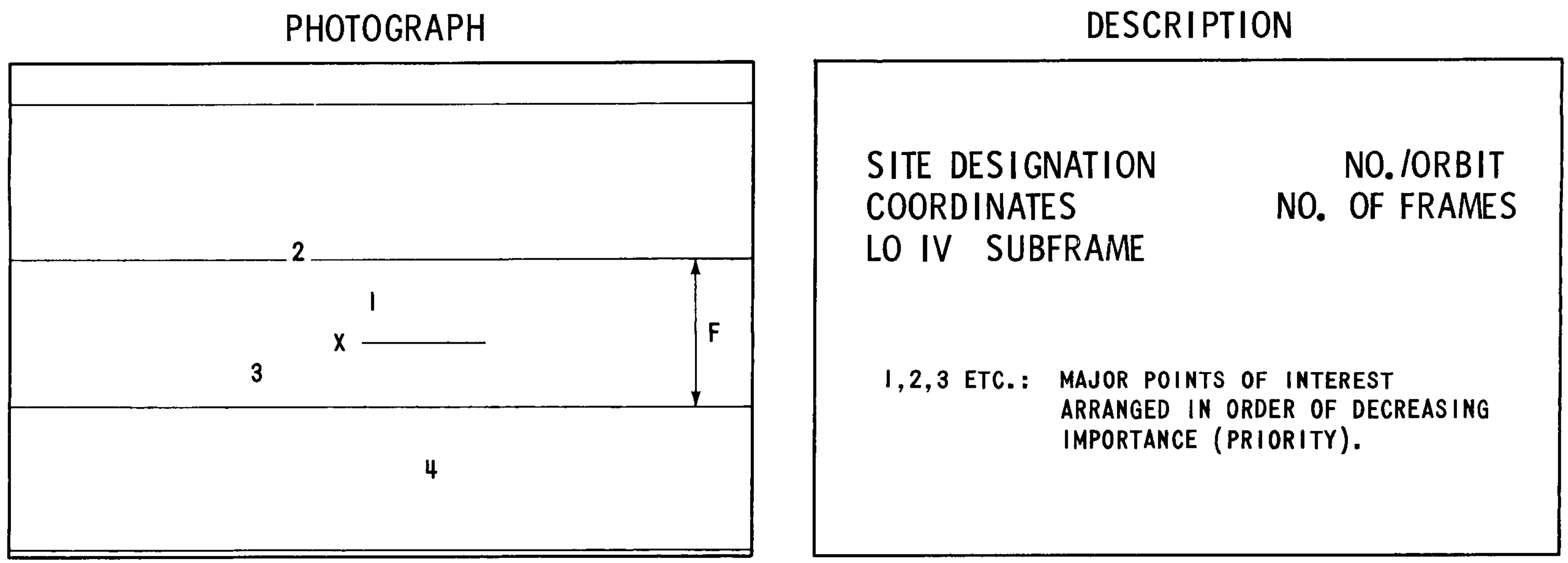
The Touchdown Point

Name	Site No.	Point No.		Distance (KM)
Littrow Rilles	1/35	1		6.4
		2		7.2*
			Sum all	13.6
			Sum 2	13.6
Dionysius	2/41	1		3.7
		2		7.4
		3		5.5*
		4		14.8
			Sum all	31.4
			Sum 2	9.2
South of Alexander	3/45	1		2.9
		2		25.4
		3		15.8
		4		14.1
		5		7.5*
			Sum all	65.7
			Sum 2	10.4
Sulpicius Gallus	4/46	1		5.7
		2		7.1
		3		3.9
		4		5.3*
			Sum all	22.0
			Sum 2	9.1
Hyginius Rille	5/47	1		8.8
		2		6.1
		3		6.4*
		4		11.1
			Sum all	32.4
			Sum 2	12.5
Hadley Rille	6/50	1		4.1
		2		6.8*
		3		7.2
		4		18.6
		5		21.3
			Sum all	60.0
			Sum 2	10.9

*Denotes second shortest distance.

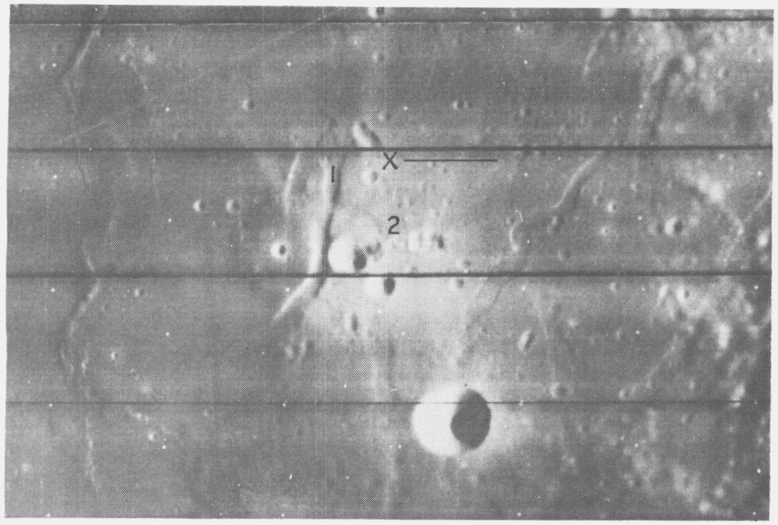
Name	Site No.	Point No.		Distance (KM)
Alphonsus	7/53	1		6.1
		2		10.9
		3		7.2*
		4		11.2
			Sum all	35.4
			Sum 2	13.3
Copernicus CD	8/59	1		4.0
		2		7.0
		3		5.3*
		4		7.3
			Sum all	23.6
			Sum 2	9.3
Fra Mauro	9/60	1		3.3
		2		6.6*
		3		7.4
		4		8.1
			Sum all	25.4
			Sum 2	9.9
Copernicus Secondaries	10/61	1		8.1
		2		15.7
		3		13.3
		4		7.6
			Sum all	44.7
			Sum 2	15.7
Copernicus A	11/63 A	1		3.4
		2		4.8*
		3		11.0
			Sum all	19.2
			Sum 2	8.2
Copernicus B	11/63 B	1		4.1
		2		3.4*
		3		3.1
		4		8.9
		5		11.7
			Sum all	31.2
			Sum 2	6.5
Imbrium Flows	12/65	1		3.4
		2		5.7*
		3		10.0
			Sum all	19.1
			Sum 2	9.1
Tobias Mayer Dome	13/69	1		2.2
		2		14.1
		3		4.7
		4		4.1
		5		11.3
			Sum all	36.4
			Sum 2	6.9

Name	Site No.	Point No.		Distance (KM)
Jura Gruithuisen A	14/76 A	1		7.9*
		2		10.8
		3		15.4
		4		11.2
		5		7.5
		6		12.08
			Sum all	64.88
			Sum 2	15.4
Jura Gruithuisen B	14/76 B	1		3.6*
		2		6.8
		3		2.8
			Sum all	13.2
			Sum 2	6.4
Aristarchus Plateau	15/82	1		3.3
		2		10.0
		3		17.6
		4		15.3
		5		7.0*
			Sum all	53.2
			Sum 2	10.3
Marius Hills	16/32	1		3.6*
		2		5.6
		3		8.8
		4		2.4
			Sum all	20.4
			Sum 2	6.0



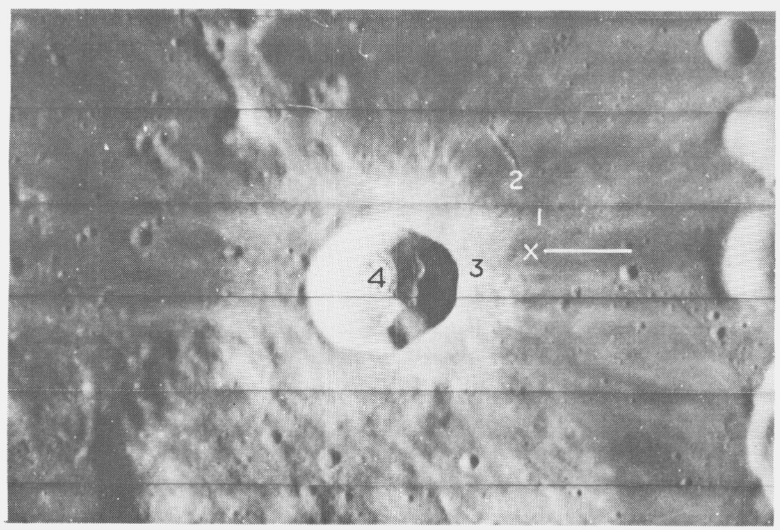
——	POSSIBLE APPROACH PATH = 10 KM
X	POSSIBLE LANDING POINT
1-4	FEATURES OF INTEREST
F	FRAMELET SEPARATION (SCALE):
	= 12 KM IN EQUATORIAL REGIONS
	= 16 KM IN POLAR REGIONS

FIGURE 2 - EXPLANATION OF FIGURES 3-10



LITTROW RILLES 1/35
29^{0} 20' E 22^{0} 12' N F4
LO-IV H-78-R

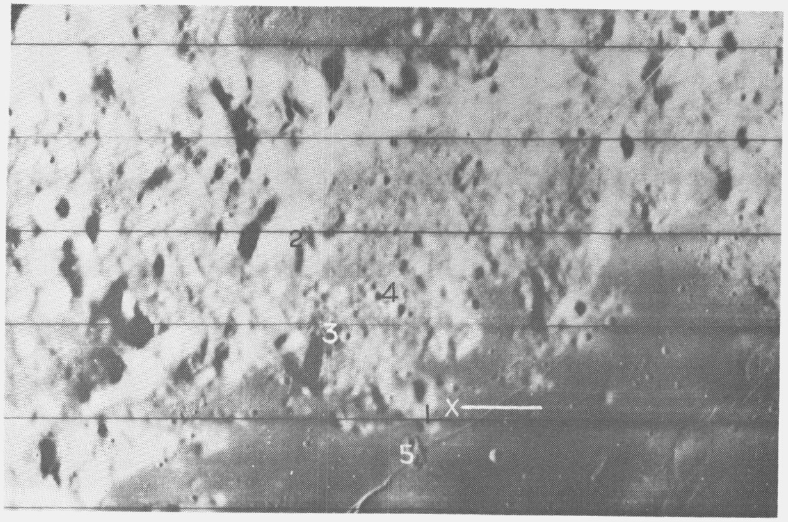
1. DARK MARE MATERIAL CUT BY RILLE, BEDDING MAY BE EXPOSED
2. BRIGHT HALO CRATERS OF IRRIGULAR SHAPE (YOUNG VOLCANICS?)



DIONYSIUS 2/41
18^{0} 00' E 2^{0} 42' N F4
LO-IV H-90-1

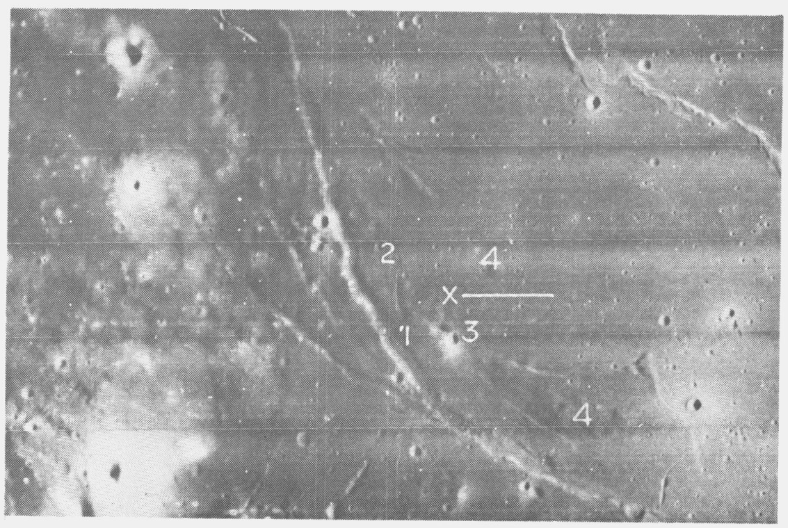
1. ALTERNATING DARK AND LIGHT RAYS
2. LINEAR RILLE CUTTING RAYS
3. BRIGHT BLANKET AND SHARP RIM
4. FLOOR OF FRESH CRATER

FIGURE 3



SOUTH OF ALEXANDER 3/45
13^0 30' E 38^0 30' N F4
LO-IV H-98-2

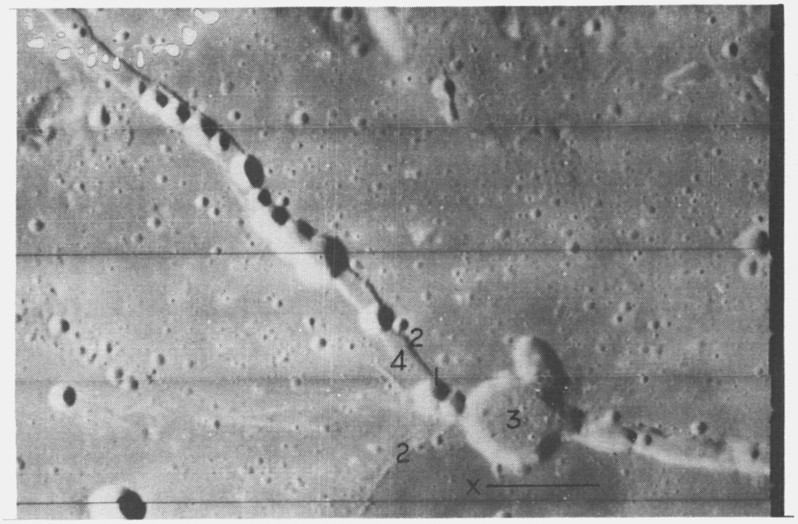
1. MARE-HIGHLAND CONTACT
2. TWO HIGHLAND TERRAINS CONTACT
3. DOMES AND SCARPS IN HIGHLAND
4. SMALL CRATERS IN HIGHLAND
5. RILLE AND CRATER CLUSTER



SULPICIUS GALLUS RILES 4/46
9^0 20' E 21^0 00' N F4
LO-IV H-97-1

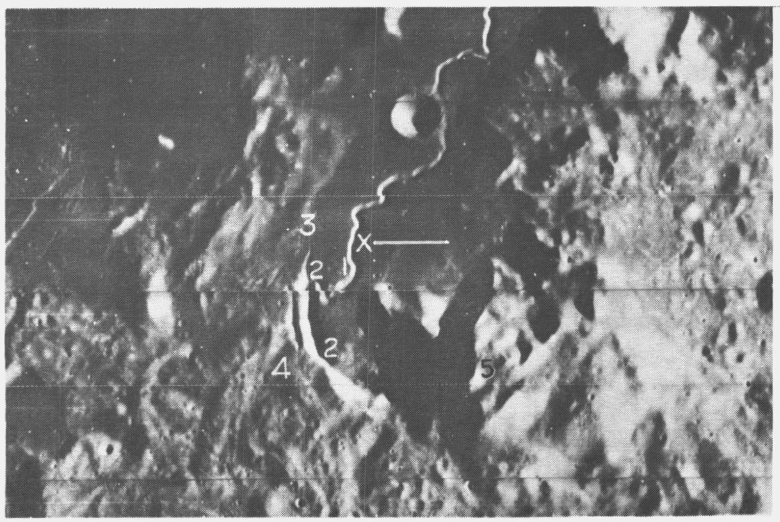
1. RILLE COMPLEX IN MARE
2. DARK MATERIAL COVERING MARE & TERRA
3. BRIGHT HALO CRATER WITH PROBABLE EXPOSURE OF BEDS
4. DOMES IN MARE MATERIAL

FIGURE 4



HYGINUS RILLE 5/47
6^{0} 00' E 8^{0} 15' N F4
LO-IV H-102-2

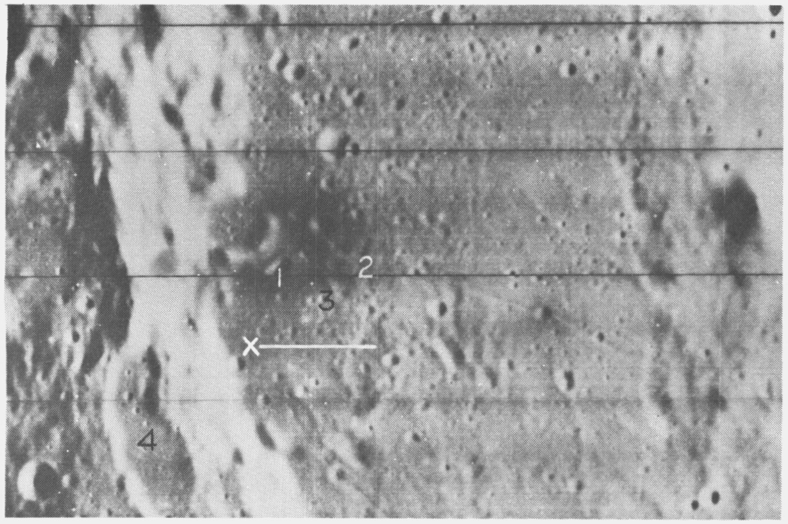
1. CRATER CHAIN - RILLE CONTACT
2. RILLE - MARE LINE
3. CRATER FLOOR
4. RILLE FLOOR



HADLEY RILLE 6/50
3^{0} 00' E 26^{0} 12' N S4
LO-IV H-102-3

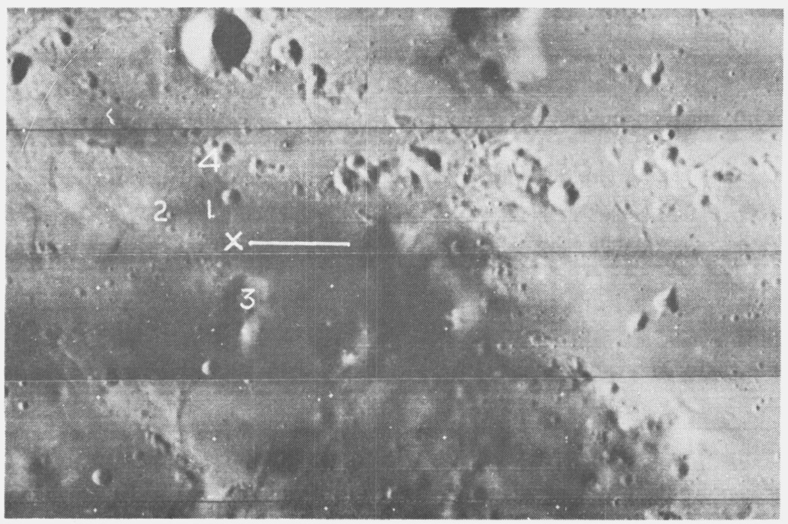
1. SINUOUS RILLE IN MARE
2. TERMINATION OF RILLE
3. MARE - HIGHLAND CONTACT
4. APENNINE BENCH MATERIAL
5. EVEN-RUGGED HIGHLAND CONTACT

FIGURE 5



ALPHONSUS 7/53
4^{0} 10' W 13^{0} 40' S F4
LO-IV H-108-2

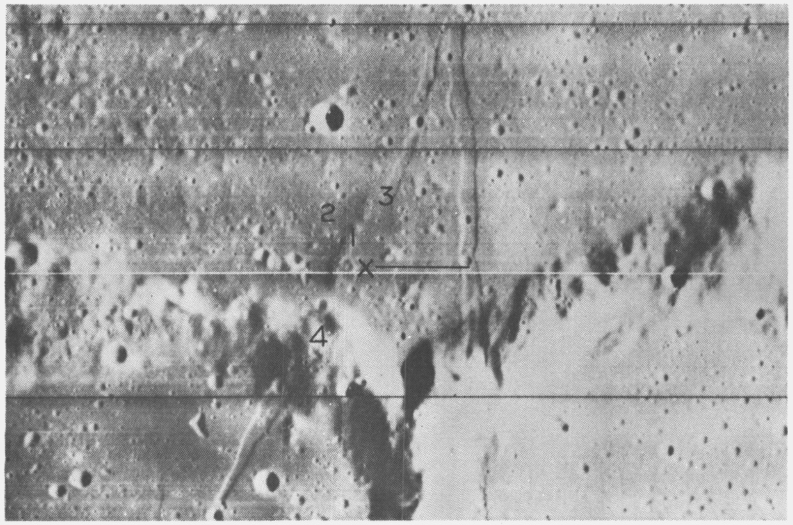
1. DARK HALO CRATER
2. RILLE IN CRATER FLOOR
3. DARK-LIGHT MATERIAL CONTACT
4. ELONGATE FEATURE ON RIM



COPERNICUS CD 8/59
14^{0} 45' W 6^{0} 25' N 1
LO-IV H-121-1 AND 2

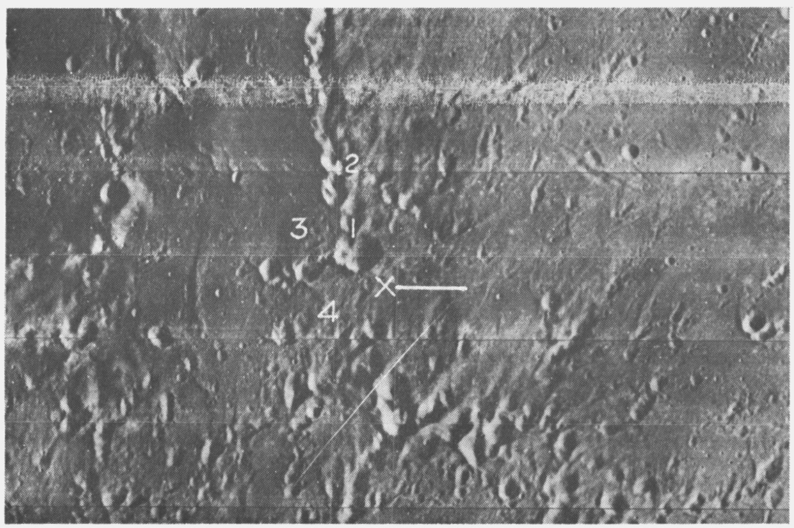
1. DARK MANTLING MATERIAL
2. DARK-LIGHT MATERIAL CONTACT
3. DOME (WITH SUMMIT CRATER)
4. SECONDARY CRATERS

FIGURE 6



FRA MAURO 9/60
16^{0} 45' W 7^{0} 00' S F4
LO-IV H-120-3

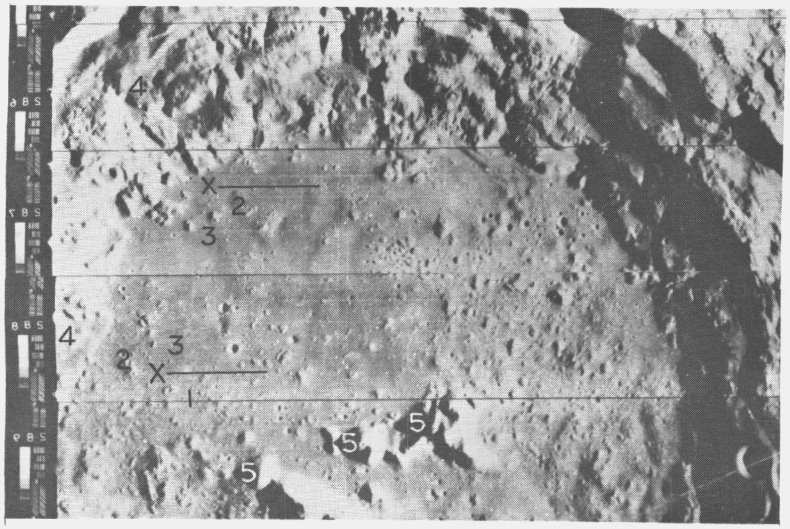
1. DOMES IN FLOOR
2. DARK-LIGHT MATERIAL CONTACT
3. FILLING OF RILLE
4. RILLE IN RIM



COPERNICUS SECONDARIES 10/61
16^{0} 15' W 14^{0} 40' N S4
LO-IV H-121-2

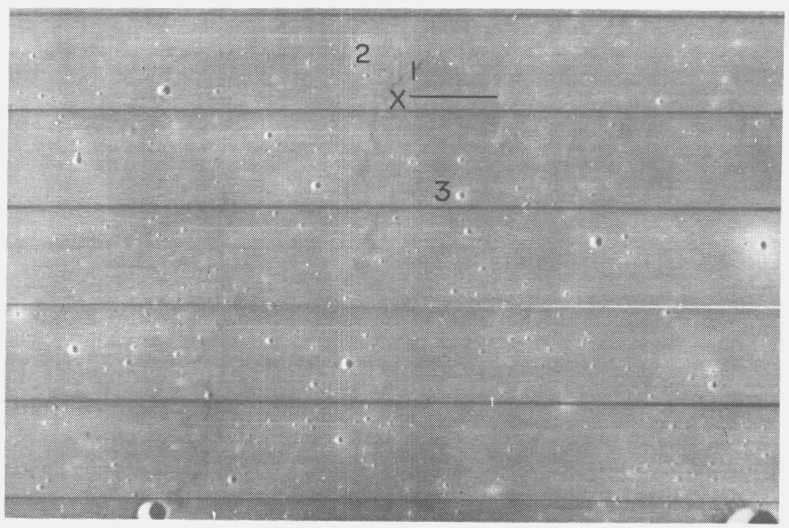
1. CRATER CHAIN
2. RAYS FROM CHAIN
3. SMOOTHER TERRAIN
4. ROUGHER TERRAIN

FIGURE 7



COPERNICUS 11/63
20^{0} 18' W 10^{0} 25' N F8
LO-IV H-121-2

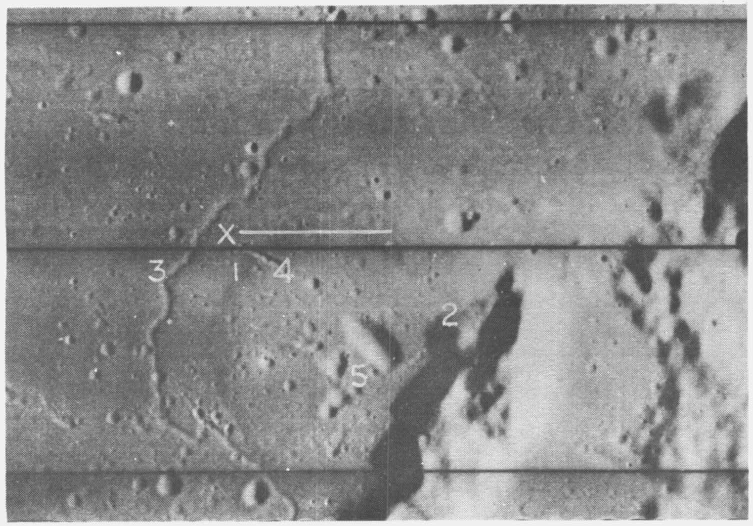
1. SMOOTH AND HUMMOCKY MATERIAL
2. DOMES IN CRATER FLOOR
3. SINUOUS RILLES IN FLOOR
4. BEDDING IN RIM
5. CENTRAL PEAKS AND CONES



IMBRIUM FLOWS 12/65
22^{0} 00' W 32^{0} 40' N F4
LO-IV H-127-L

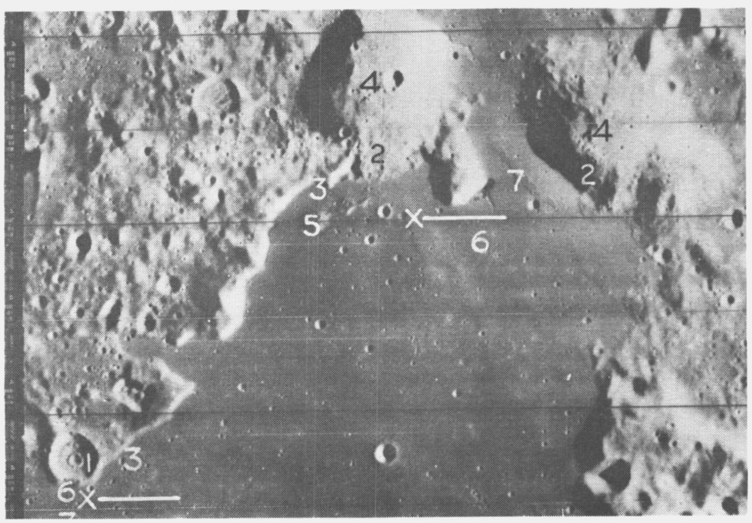
1. CONTACT BETWEEN TWO FLOWS
2. SMALL CRATERS IN MARE
3. BRIGHT HALO CRATER

FIGURE 8



TOBIAS MAYER DOME 13/69
30^{0} 55' W 13^{0} 10' N F4
LO-IV H-133-2

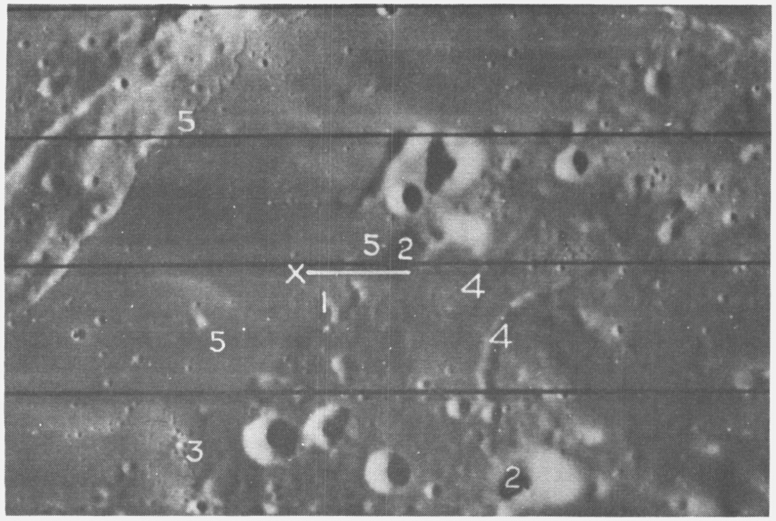
1. DOME - MARE CONTACT
2. DOME - TERRA CONTACT
3. SIMUOUS RILLE
4. CRATER CHAIN
5. SUMMIT CRATERS



JURA-GRUITHUISEN 14/76
41^{0} 30' W 35^{0} 55' N F4
LO-IV H-145-1

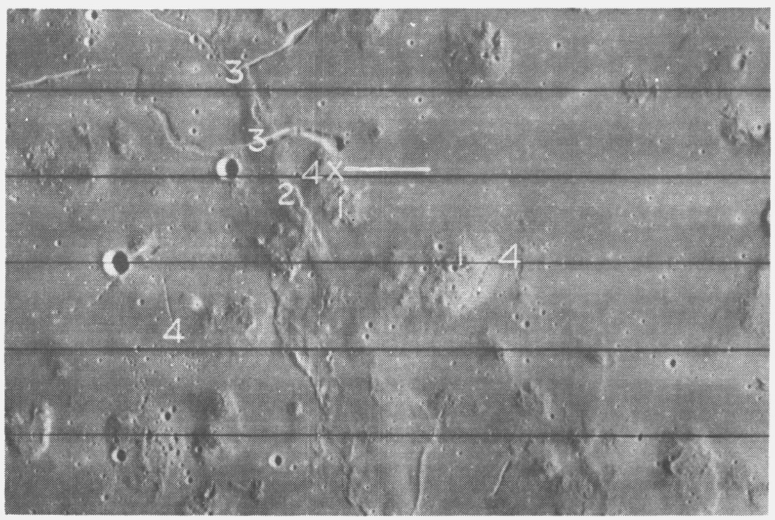
1. PANCAKE CRATER INTERIOR
2. DOME IN HIGHLAND
3. MARE - HIGHLAND CONTACT
4. SUMMIT CRATER
5. DOME IN MARE
6. SIMUOUS RILLE IN MARE
7. WRINKLE RIDGE

FIGURE 9



ARISTARCHUS PLATEAU 15/82
52^{0} 45' W 28^{0} 00' N F4
LO-IV H-158-L

1. MARE - TERRA MANTLE CONTACT
2. CONES AND DOMES
3. CRATER CHAIN
4. RILLE IN TERRA
5. RILLE IN MARE



MARIUS HILLS 16/83
56^{0} 00' W 13^{0} 45' N F8
LO-IV H-157-C

1. DOMES IN MARE
2. FLOW FRONTS
3. SINUOUS RILLE
4. CRATER CHAINS

FIGURE 10

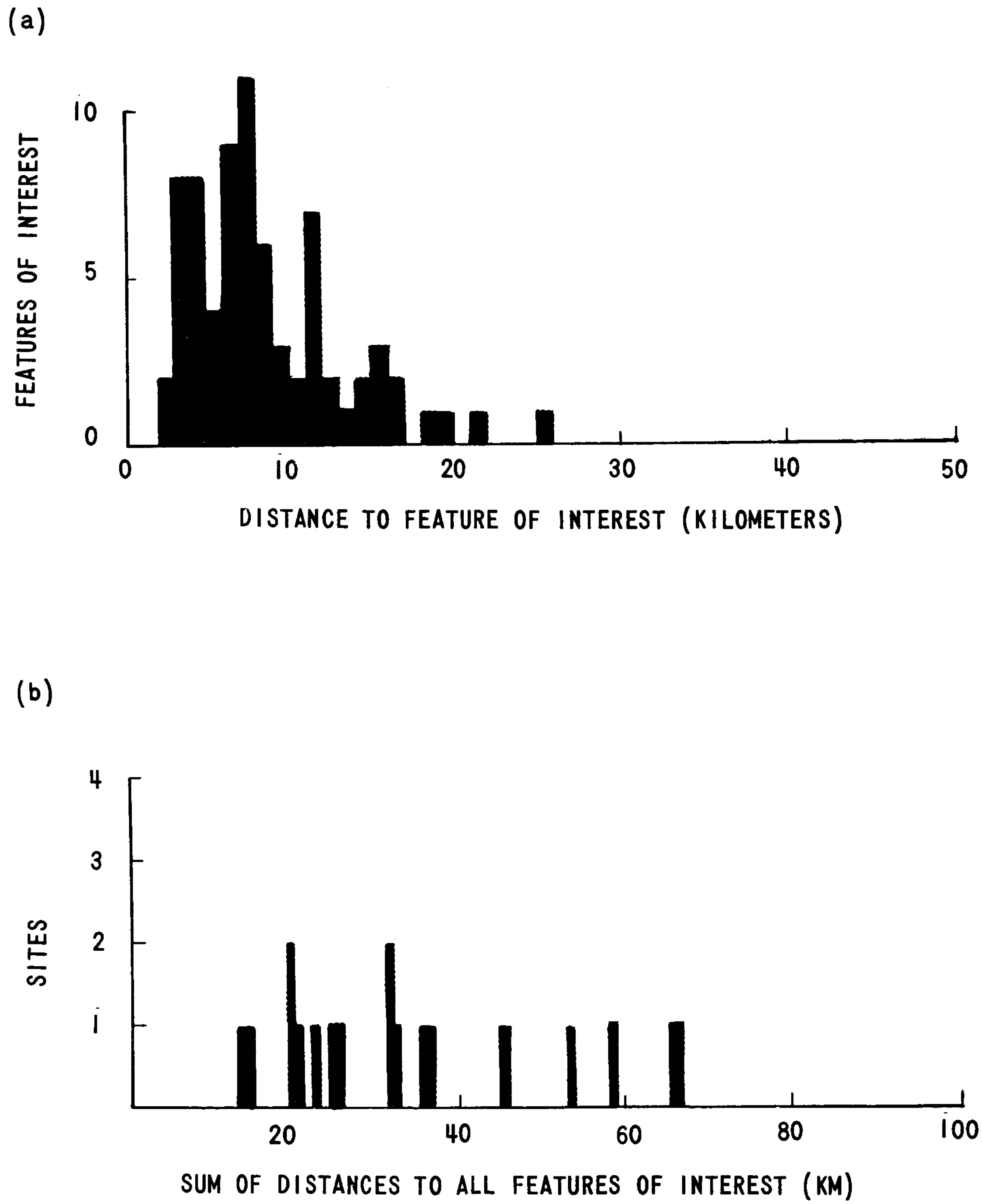


FIGURE II - COMPLETE MISSION

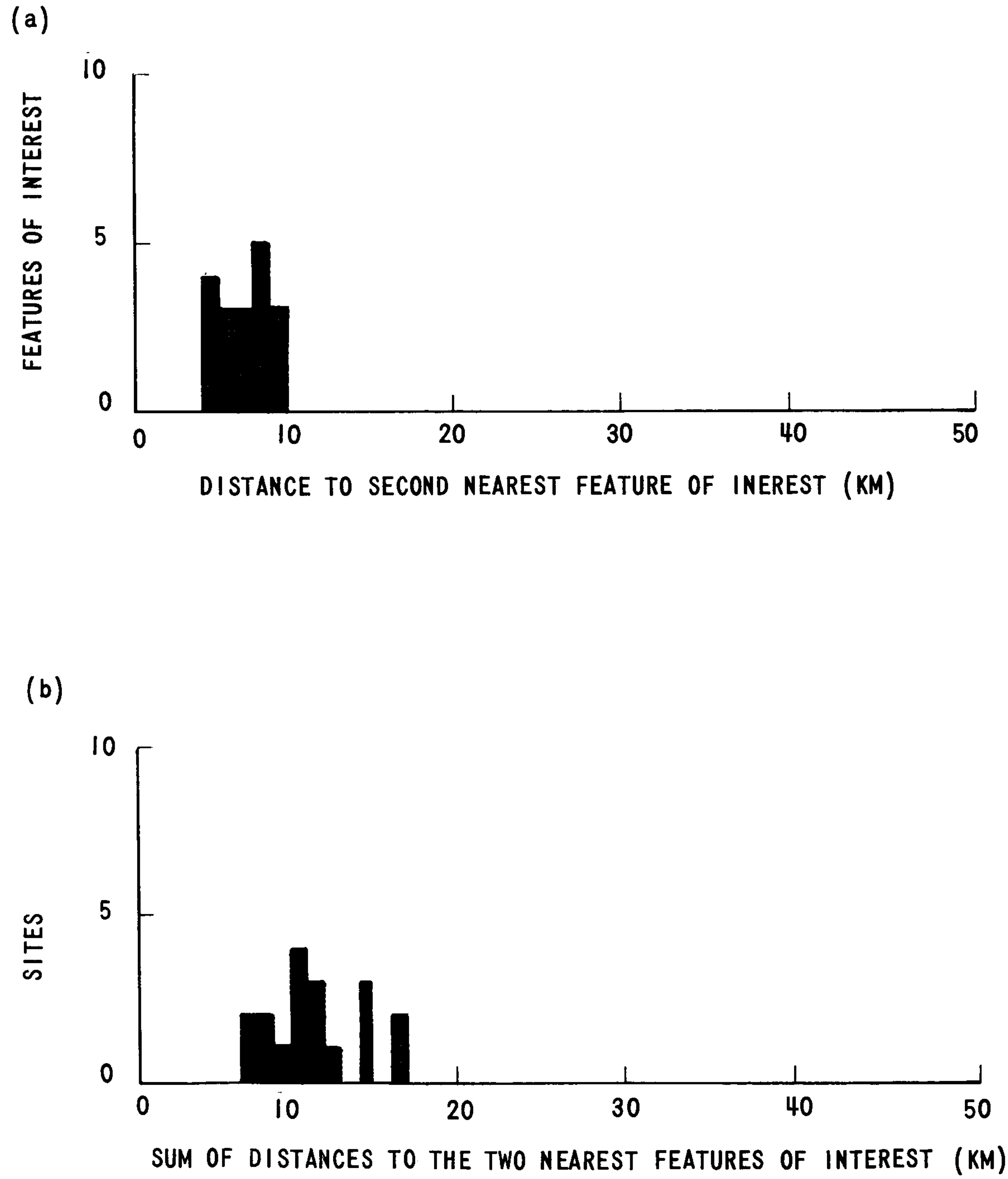


FIGURE 12 - 2-FEATURE MISSION

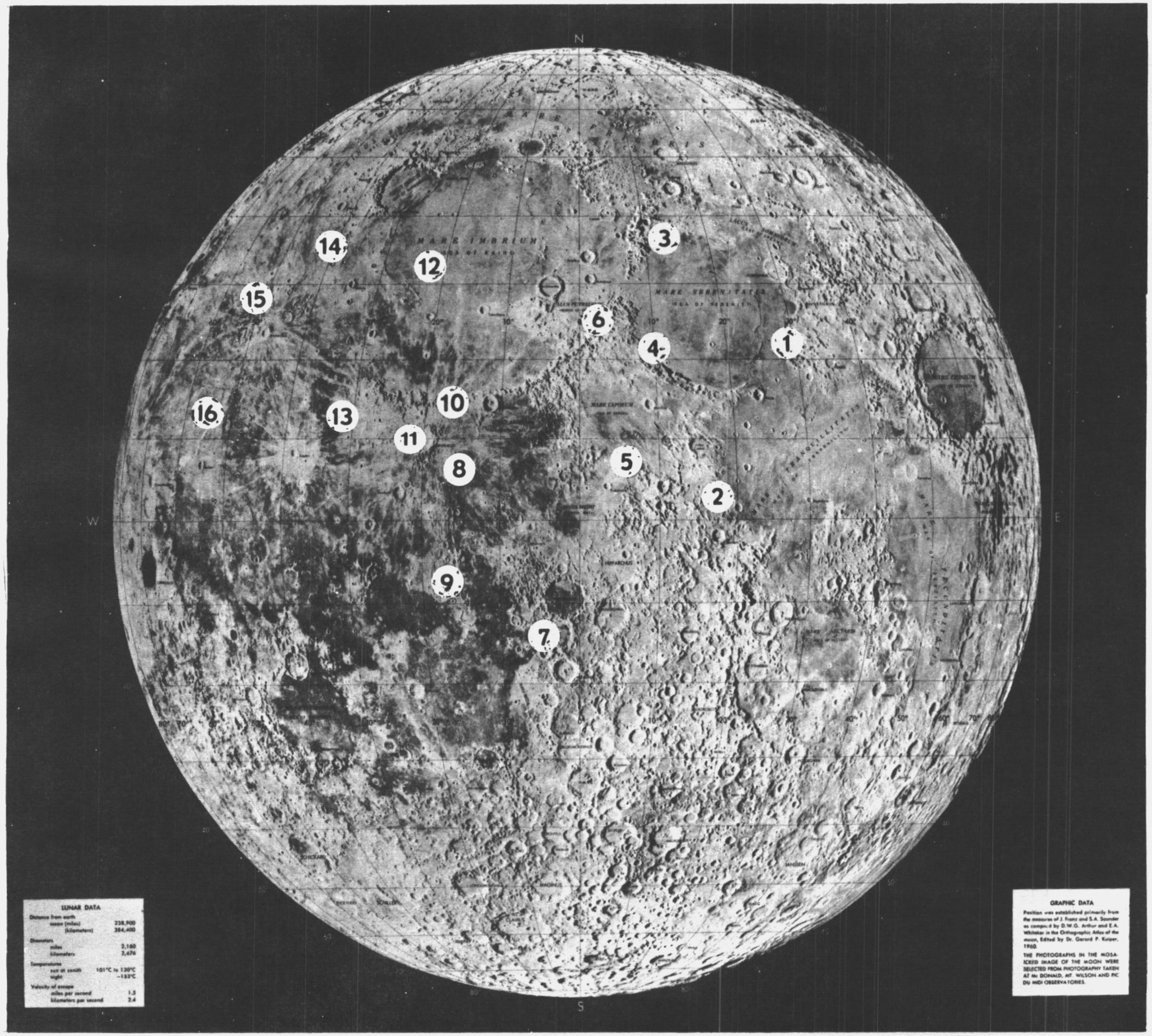


FIGURE 1 INDEX MAP
OF LUNAR ORBITER V
AAP LANDING SITES

NO.	DESIGNATION
1/35	LITTROW
2/41	DIONYSIUS
3/45	S.ALEXANDER
4/46	SULP.GALLUS
5/47	HYGINUS R.
6/50	HADLEY R.
7/53	ALPHONSUS
8/59	COPER. CD
9/60	FRA MAURO
10/61	COPER.SECON.
11/63	COPERNICUS
12/65	IMBR. FLOWS
13/69	TOBIAS MAYER
14/76	JURA-GRUIT.
15/82	ARISTARCHUS
16/83	MARIUS HILLS

BELLCOMM, INC.

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Case 232

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